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ERODED SOILS NEED *Phosphorus*

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WHEN THE top soil has washed away or blown away—crop yields drop. Most farmers know this. But just why won't the subsoil produce as well as the original top soil? Is there any particular element that we can add to eroded soils which will step up crop yields? These are questions we have been looking into at the Iowa Station.

For several years we have been making tests out over the state comparing yields of corn on eroded and non-eroded soils. These tests have shown that:

1. Yields on some soil types are often less than one-half as large on severely eroded as on non-eroded soils.

2. One of the causes for the lower yield on eroded soils is that the subsoil which remains after the top soil has washed away has too little available phosphorus.

3. The difference in yield from eroded soils depends on the type of soil.

4. The drop in yield will be less when good crop rotations are followed and when lime, manure and fertilizers are used.

We reached these conclusions after we had checked corn yields on soils with normal depths of top soil, with part of the surface soil eroded and when nothing but the subsoil remained. We did this in a number of counties over a period of a half dozen years and on several different types of soil.

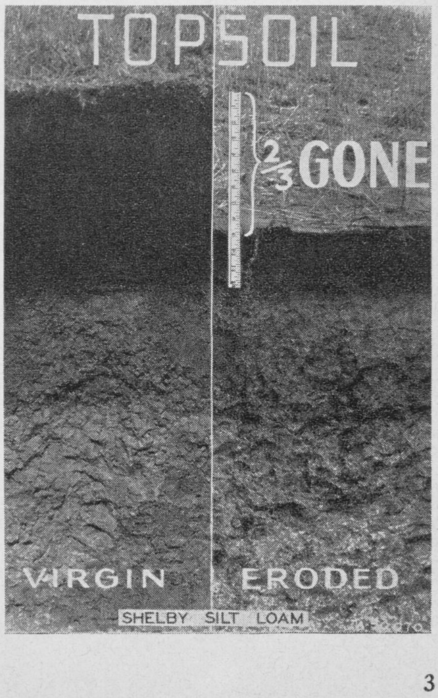
With definite proof that soil erosion will result in lower yields, we wondered to what extent this might be explained by a difference in the amount of available phosphorus. We knew that the physical structure of eroded soil is poorer and that there is less organic matter. We suspected that the amount of available plant food is probably much lower.

In order to determine the effect of erosion on the phosphorus needs of the soil, experimental work was done with some of the same soils with which we had made extensive field tests to determine the effect of erosion on yields. We can say from these studies that the lower yield of corn on eroded soils is at least partly due to a lack of sufficient phosphorus for best plant growth. We reached this conclusion after making tests in the greenhouse and in the laboratory with soils on which we had obtained yield data.

The soils we studied in the greenhouse were "paired" samples, taken from 24 fields in which we had obtained the yield of corn according to the depths of top soil. By "paired" samples we mean that we used a sample of an eroded soil and of one not eroded out of each field. Each of these pairs of samples was on the same soil type and each field had been in the same rotation and uniformly treated.

Enough soil was obtained to fill six 2-gallon pots. We added 20 percent superphosphate at a rate of 400 pounds per acre to half the pots, leaving the other three untreated. Sudan grass was then

Above: Up-and-down-hill farming is taking away the top soil which is best phosphorus source. Below: When the thin top soil of Shelby silt loam is gone, most of the phosphorus available to plants is gone.



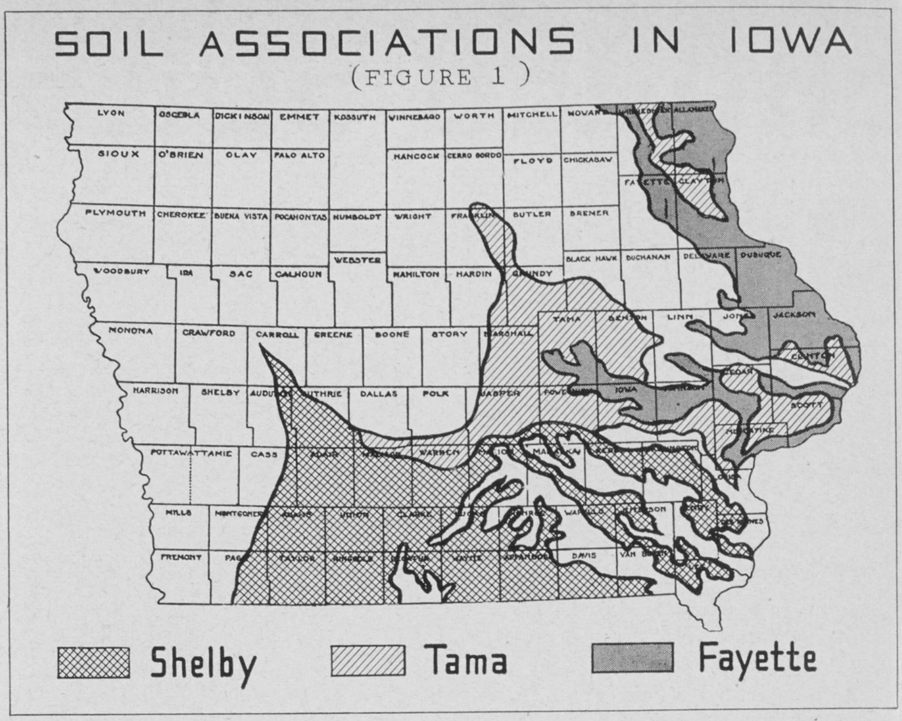
grown and yields obtained to find the soil's need for phosphorus. Enough nitrogen and potash were added to insure that these elements would not be limiting.

Test Three Soil Types

This test was made with three of the major soil types of the state: Fayette silt loam, Tama silt loam and Shelby loam. Fayette silt loam occurs commonly in the more rolling areas of such northeast Iowa counties as Allamakee, Clayton, Dubuque and Jackson. (See accompanying map of Iowa.) It is a light brown or grayish-brown soil which was formerly timbered and which never had a very deep top soil.

Tama silt loam is found in the gently rolling areas of central and east central Iowa and is typical in Marshall, Tama, Poweshiek and Cedar counties. This soil is dark brown to black in color and was originally covered with tall grasses. In the rolling areas of southern Iowa in such counties as Lucas, Decatur, Wayne and Ringgold, the Shelby loam is found. It is dark grayish-brown in color and once had tall grasses on it.

The yield of corn in the field taken on these soils was much lower when the top soil had been eroded than when it was of normal depth. (See table 1.) The greatest decrease occurred on the Shelby loam, the second on the Tama silt loam, and the least on the Fayette silt loam. Since these yields were taken in 1941 on the Tama silt loam and in 1942 on the Fayette silt loam and Shelby loam, they are not exactly comparable.



Above are shown the location of the three soils used in this study.

Higher corn yields are usually obtained on Tama silt loam than on the other two soils and the lowest are on the Shelby loam. The percentage decrease in yields because of erosion is greatest for the Shelby loam and least for the Fayette silt loam. The yield decrease on the Tama silt loam is between the decreases on the other two soils. The amount of decrease, at least in part, is because of the nature of these soils. The Shelby loam has a shallow surface layer below which is a heavy and tight material known to be low in available plant nutrients. The surface layer is deeper and the subsoils are better in texture in the Fayette and Tama soils.

Greenhouse Test Results

The growth of sudan grass on these soils when placed in pots in the greenhouse indicated that the differences in yield are due to a greater lack of phosphorus available for plants on the eroded soils. (See table 2.) The growth of the plants showed that all of the soils needed phosphorus whether eroded or not, but the need for phosphorus was greater when they were eroded.

There was an interesting difference between the three soils. The Fayette silt loam gave the least response when phosphate was added, and there was not much difference between the response of the eroded and non-eroded samples to phosphate fertilizer. This corresponds with the corn yields in the field. Fayette corn yields dropped 15 bushels because of erosion as compared with a 51-bushel drop on the Shelby.

The greatest response in the growth of sudan grass from the use of phosphate fertilizer occurred with the Shelby loam which had been eroded, indicating a definite lack of available phos-

Phosphate fertilizer gave most response in Shelby, least in Fayette.

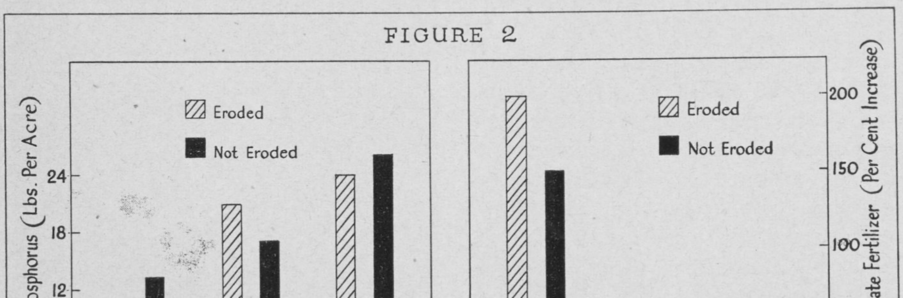


TABLE I. THE INFLUENCE OF DEPTH OF TOP SOIL ON THE YIELD OF CORN.

		Yield of corn in bushels per acre	Percent decrease from erosion
Tama silt loam	eroded	41.7	39.7
	non-eroded	69.2	
Fayette silt loam	eroded	63.4	18.4
	non-eroded	78.2	
Shelby loam	eroded	28.5	64.0
	non-eroded	79.1	

TABLE II. YIELD OF SUDAN GRASS ON ERODED AND NON-ERODED SOIL WITH AND WITHOUT PHOSPHORUS.

		Yield of sudan grass in grams per pot			
		Without phosphorus	With phosphorus	Increase for phosphorus	Percent increase
Tama silt loam	eroded	34.2	54.0	19.8	58
	non-eroded	46.1	56.5	10.4	23
Fayette silt loam	eroded	15.1	19.4	4.3	28
	non-eroded	15.2	18.2	3.0	20
Shelby loam	eroded	7.2	21.5	14.3	199
	non-eroded	7.8	19.5	11.7	152

phorus and a reason for the decrease in the yield of corn as we found it in the field. Our greenhouse test showed that all of these soils were low in available phosphorus and that erosion of the top soil had aggravated the condition.

Check Chemical Test

Another type of test commonly used to indicate the available phosphorus content of soils is a chemical one based on the amount of phosphorus extracted from the soil by a dilute acid. Most of the so-called quick tests for available phosphorus operate upon this principle. Since we were also interested in finding out how the chemical test compared with the greenhouse test, samples of these soils were tested in the laboratory for their content of acid-soluble phosphorus. The results of these tests are compared with the greenhouse tests in the accompanying chart.

In agreement with the greenhouse tests, the chemical tests showed that, on the average, the Fayette soils contained more available phosphorus than the Shelby soils and that the non-eroded soils tended to have slightly larger amounts of available phosphorus than the eroded samples. The Tama soils, which contained somewhat smaller amounts of available phosphorus than the Fayette soils according to the greenhouse test, also showed smaller amounts in the chemical test.

In the case of the Tama soils, however, the average phosphorus content of the eroded soils as determined by the chemical tests was larger than that of the non-eroded soils, yet the greenhouse test showed that the eroded soils are more deficient in phosphorus. Although the chemical test showed that certain soil types contain on an average more available phosphorus than others, it failed to show that eroded Tama soils are more phosphorus-deficient than the non-eroded soils. Other studies we have made also show that this test is not very satisfactory as a sole means of determining the phosphorus fertilizer needs of individual soils.

One of the possible reasons for the weakness of the chemical test when applied to individual soils is that it does not measure the amount of phosphorus in the soil organic matter which becomes available to plants as the organic matter decomposes. Since about one-half of the total phosphorus in the surface layers of Iowa Prairie soils is in the organic matter, this may be of considerable importance in supplying phosphorus to the growing plant.

Some information on the amounts of organic phosphorus lost by soil erosion was obtained in a study of the eroded and non-eroded Tama soils. This study showed that the organic phosphorus content of the non-eroded soils averaged 554 pounds per acre, whereas the content of the eroded soils averaged only 454 pounds per acre. The larger amounts of organic phosphorus in the non-eroded Tama soils probably explain, at least in part, why these soils were less phosphorus-deficient than the eroded soils.

Since the results we obtained in the greenhouse and in the laboratory agreed very well with the yield tests in the field, we are led to the conclusion that one reason why low yields are the rule when crops are grown on eroded soils is that the phosphorus in the subsurface soil layer is not as readily available to the plant as that in the surface soil.

Other reasons undoubtedly are that eroded soils are lower in the amount of nitrogen and possibly potassium, especially in an available form. They also have a lower content of organic matter and are generally of such physical structure as to prevent the best plant growth.

Phosphorus fertilizer will help, but it cannot fully restore such badly eroded fields as this.